Cold-wave warnings were issued for Oklahoma, 8:30 p. m. of the 22d, and repeated and extended to extreme northwestern Arkansas at 9 a. m. of the 23d, and were extended at 3 p. m. over Arkansas and the interior of Texas, and were repeated at 8:30 p. m. for Arkansas and Dallas and Palestine, Tex.; the warning was extended at 9 a. m. of the 24th to the coast; these warnings were generally justified.

Frost or freezing warnings were issued for portions of the southern part of the district on the 4th, 5th, 8th, 9th, 10th, 17th, 25th, and 31st. Fire-weather warnings were issued on the 3d, 19th, and 23d.—*I. M. Cline.*

DENVER FORECAST DISTRICT.

With the exception of a storm which appeared over Idaho on the afternoon of the 1st and moved rapidly southeastward across the district, the first half of the month was characterized by settled weather, under the influence of high pressure in the Plateau region. During the latter part of the month low pressure and unsettled weather prevailed west of the mountains, while a succession of cold anticyclonic areas occupied the northeastern slope.

The storm which appeared over Idaho on the afternoon of the 1st moved rapidly southeastward, overspreading both slopes of the Rocky Mountains by 8 a. m. of the 2d, with barometer readings more than 0.5 inch below the normal. The disturbance was followed by an unusually sharp rise in pressure in the North Pacific States. Warnings of a moderate cold wave were issued for Utah, northern and western Colorado, northern Arizona, and northwest New Mexico on the 2d. The temperature fell 10° to 16° in the greater part of Colorado and New Mexico and was well below the freezing point. The coldest weather following the storm did not occur, however, until the morning of the 4th, when the readings in the greater part of the area for which warnings were issued ranged from 2° to 14° above zero. An area of low barometer developed in the northern Rocky Mountain region on the 15th, being central at 8 p. m. in northeastern Colorado. Cold-wave warnings were issued for eastern Colorado. The warnings were justified, the prevailing temperatures ranging from zero to 14° above zero on the morning of the 17th. A cold wave also occurred in northeastern Arizona, extreme southwestern Colorado, and parts of New Mexico.

Another area of low pressure of considerable intensity appeared over Nevada on the 18th, with an area of high pressure over Alberta. Cold-wave and live-stock warnings were issued for eastern Colorado and extreme eastern New Mexico. Although the anticyclonic area moved very slowly southward and eastward, the western disturbance remained central on the Pacific coast, having apparently recurved to the northeastward before reaching the coast. While the falls in temperature were not great, colder weather prevailed in eastern Colorado, with temperatures ranging from 5° to 20° above zero on the mornings of the 19th and 20th. Unsettled weather, with local rain or snow, prevailed in Utah, western Colorado, and northern Arizona from the 18th to the 23d under the influence of this disturbance. On the evening of the 22d another cold anticyclonic area was overspreading the northeastern slope, while the western disturbance had apparently concentrated as a deep center of depression in southwestern Utah. Warnings of a cold wave were distributed for Utah, Colorado, northern Arizona, and northern and eastern New Mexico, and heavy snow for Utah, Colorado, northeastern Arizona, and northern New Mexico. Heavy snow occurred in parts of Utah and Colorado and a cold wave in the greater part of the area for which warnings were issued. Zero temperature was reported on the morning of the 24th at Flagstaff, and the temperature was 6° to 8° below zero in northeastern Colorado. A cold-wave warning issued for southeastern and extreme eastern New Mexico on the morning of the 24th was followed by a sharp fall in temperature with readings close to 20° above zero in southeastern New Mexico. Heavy snowfall warnings were issued for Utah and northern Arizona on the morning of the 25th, an area of unusually low pressure having appeared on the middle Pacific coast. The disturbance decreased in intensity, however, and failed to move inland. Moderate to heavy precipitation was confined to western and central Arizona.—*Frederick W. Brist.*

SAN FRANCISCO FORECAST DISTRICT.

The pressure distribution controlling the weather over the Pacific Slope during December, 1921, was of two entirely different types, and each covered practically one-half of the month. During the first portion of the month the pressure was low over Alaska, the British possessions and the north Pacific Ocean and high over the southern Plateau, California, and the ocean to the west and storms from the north Pacific entered the continent at a high latitude. This is the typical distribution for fair weather in California and the Plateau, light rain in western Oregon and seasonable rain in Washington.

The latter part of the month presented a complete reversal of the pressure distribution. A large sluggish area of high pressure covered Alaska, the British possessions, North Pacific Ocean, and Rocky Mountain region, and caused storms from the ocean to be forced far south of their usual path and enter the continent through California. This is the typical condition for heavy precipitation over California and the Plateau. Hence, the first part of the month gave moderate precipitation in western Washington and northwestern Oregon, and the latter part heavy precipitation in California and the Plateau region.

The storm from the 18th to the 27th did a large amount of damage to highways, bridges, and railroads in southern California by floods, washouts, and landslides. The gale on the 25th in the San Francisco Bay section prostrated telegraph and telephone lines, uprooted many trees, unroofed several houses, and interfered with the ferry services on the bay. On the 20th, while about 900 miles off the California coast en route to Honolulu, the Japanese freighter, *Texas Maru*, was severely damaged by gales and high seas and the first and third officers were washed overboard.

Storm warnings were ordered 15 times, small craft 2, and advisory warnings 4. Frost warnings were issued in California 9 times and a cold-wave warning in eastern Washington and northern Idaho on the 18th.—*G. H. Willson.*

627.41(73)

RIVERS AND FLOODS.

By H. C. FRANKENFIELD, Meteorologist.

Mention of the Ohio River flood of late November and early December was made in the MONTHLY WEATHER REVIEW for November, but no data were given for points south of Mount Vernon, Ind.

The crest of the flood passed into the Mississippi River on December 8, but as the Cumberland and Tennessee Rivers contributed only relatively small volumes of water, there were no flood stages reached below the vicinity of Shawneetown, Ill. At this place, however, where the gauge heights showed the full effect of the Wabash and White Rivers floods, the crest stage was 39.6 feet, or 4.6 feet above the flood stage, on December 8. Farther down the river the crest stages were from 8 to 9 feet below the flood stages.

In the vicinity of Shawneetown there was a crop loss of about $5,000, while other crops and stocks to the value of $25,000 were saved by the warnings.

There was a second and more severe flood in the Ohio River during the last week of the month. It was caused by general and heavy rains from December 22 to 24, throughout the principal drainage area of the river, except the Cumberland and the Tennessee River districts. On December 24 and 25, there was a decided fall in temperature, and over the upper drainage area the rain changed to snow, thereby checking the rise in the river. As a result, flood stages were not reached above the mouth of the Great Kanawha River, Pittsburgh reporting 21.2 feet at 8 a. m., December 25, and Parkersburg 32 feet at 8 a. m., December 26.

There were, however, general floods in the rivers of West Virginia and eastern Kentucky, the crests ranging from 1 to 9 feet above the flood stages.

From the mouth of the Great Kanawha River to below Shawneetown, Ill., flood stages were general, except in the immediate vicinity of Louisville, Ky., the crest stages ranging from 2 to 9.3 feet above the flood stages, the latter in the vicinity of Shawneetown as a result of the considerable increment from the White River. It should be mentioned that the flood waters from the Licking River of Kentucky added from 3 to 4 feet to the Cincinnati crest of 56.1 feet. It is interesting also to note that the precipitation causing this flood was heaviest near the main stream and along the middle course, and comparatively light over the upper tributary basins, with a resulting flat crest over the middle section.

The floods in the Muskingum and lower Scioto Rivers were moderate and no damage was done, but the Hocking River flood was more marked, although with but little resulting damage.

The flood in the lower White River of Indiana was more pronounced, but owing to the lateness of the season and the timeliness of the warnings, little damage was done.

The Illinois River remained above the flood stage from Peru to Beardstown throughout the month, but the stages were not high enough to cause any damage.

Warnings of all these floods were issued promptly and in the main they were very accurate, especially those for the main stream. The total of losses and damage was small, aggregating, so far as was reported, only about $37,000, while the value of property saved estimated at $540,000, of which $500,000 was in the Cincinnati district.

There were no other floods of consequence east of the Rocky Mountains.

The Mississippi was frozen above St. Paul, Minn., at the end of the month, but was open below. Light running ice was reported as far south as Dubuque, Iowa, during the last week of the month. The Missouri River was generally frozen above Pierre, S. Dak., but was open at Pierre after December 14, and floating ice was observed as far south as Omaha, Nebr.

Severe and destructive floods occurred in the rivers of western Washington from December 12 to 16, inclusive, and the following report thereon was prepared by Mr. G. N. Salisbury, official in charge of the Weather Bureau Office at Seattle, Wash.

Floods in Washington—G. N. Salisbury, Meteorologist, Seattle.—This flooding of river valleys and lowlands was the combined effects of excessive rains and warm winds of the nature of Chinooks on both slopes of the Cascades, the floods not extending east of the Columbia River. The rains began on the 8th and 9th and the flood stage on the western slope began on the 12th or 13th, while on the eastern slope the flood stage was reached a day later. Practically all of the snow was melted to the summits on the western slopes and 18 to 24 inches from the eastern slope in three days.

At Snoqualmie Pass, the headwaters of the Snoqualmie River, the precipitation, mostly from rain, was 12.15 inches in five days, of which 11.75 inches occurred on the 10th, 11th, and 12th. Maximum temperatures of 55° to 60° were reached at most stations from the 10th to 12th. An average of 5.50 inches of precipitation occurred in three to four days in the flooded district, which was all of Washington from the coast to the one hundred and twentieth meridian, and from the Lewis River in latitude about 47° northward to the international boundary.

The principal rivers in flood east of the mountains were the Yakima, Wenatchee, and Stehekin, all heading in the Cascades. The high water was due entirely to Chinooks and excessive rains in the mountains near the summit, as there was no heavy precipitation in the lower reaches below Cle Elum on the Yakima or Leavenworth on the Wenatchee.

The Yakima is said to have reached the highest stage on record, although the consequent money loss was small. The reclamation project manager at Yakima estimates the entire damage to reservoirs and canals as $2,000, and the county engineer reports $1,000 as the loss to bridges and highways.

The damage in Kittitas County was slight. There were two deaths from drowning in the Yakima.

Some damage was occasioned by the high waters of the Wenatchee; four or five small cottages at Cashmere being washed away, but the money loss was not great.

The greatest damage occurred west of the Cascade Mountains, owing mainly to the nature of the country. The distance from the mountain summits to tidewater is so short that freshets come suddenly and there is scarcely a day in which to prepare; also the dikes near tidewater give way under the burden of the freshets, thus increasing the inundation. A great share of the damage and nearly all the loss of life was due to landslides caused by the excessive rain. The soil in western Washington being a glacial drift of clay and gravel loam overlying deposits of blue clay, the bluffs, banks, and cuts, although so solid as to be practically hardpan in dry weather, become softened by excessive rains. The blue-clay stratum attains the consistency of soft soap when saturated by excessive rains, and the banks slide down, often carrying houses and covering stretches of highway and railroad tracks. Experience has shown that the danger limit of saturation is in excessive rains of 2.50 inches in 24 hours. Six deaths occurred near Aberdeen from such a landslip in the recent storms, carrying a logging train down an embankment and burying the passengers. Four deaths were caused at Seattle by bluffs thus sliding, and several

were injured or endangered. Only two deaths occurred in western Washington from drowning in the flood. They were caused by a mail train from the east crashing through a broken bridge, at Miller River near Skykomish on the first day of the flood, December 12.

The inundation at Stanwood near Skagit Bay was principally due to the bursting of dikes; first on the Stillaguamish River, which was in flood, and a day or two later a dike which protected the little city from the overflow of the Skagit River let a wall of 8 feet of water loose, which caused a depth of 3 feet of water in the principal streets of Stanwood, a small town of about 1,000 inhabitants. Business was suspended for two or three days, and people went about the streets in boats. But there was no loss of life, and the property loss was small, amounting to about $5,000 from the suspension of business, so the postmaster reports. The cost of repairs to dikes is unknown. Florence and Silvana, small towns a few miles above Stanwood, suffered only slightly from loss of wages.

The greatest damage (by counties) occurred in Puyallup, White, Green, and Snoqualmie, in Snohomish, King, Pierce, Skagit, and Whatcom Counties, traversed by the Puyallup, White, Green, Snoqualmie, Stillaguamish, Snohomish, Skykomish, Skagit, and Nooksack Rivers. Grays Harbor, Pacific, Thurston, Lewis, Kitsap, Jefferson, and Clallam Counties suffered relatively small losses. The Snohomish County engineer estimates the damage to bridges and highways at $100,000; live stock and property, $10,000; crops, $10,000; suspension of business, $50,000. The King County engineer estimates the damage to roads and bridges at $125,000. The loss to Seattle from breaks in sewers, slides, etc., is not included in the engineer's estimate. The Whatcom County engineer estimates the loss to bridges at $7,000; this does not include all the loss in Whatcom County. The postmaster at Skykomish estimates the loss to bridges and highways in his vicinity at $20,000. The loss in the delta of the Skagit to stored crops, such as many tons of hay and thousands of sacks of oats, was several thousands of dollars. One farm alone lost $7,000. The loss of live stock in Whatcom, Skagit, and Snohomish Counties was considerable, but figures can not be given. The loss to highways and bridges in Kitsap County was placed at $100,000, but this is probably an overestimate and $50,000 would amply cover it. The loss in Jefferson and Clallam Counties, also Grays Harbor and Pacific Counties was considerable. Reports of the engineers of Skagit, Pierce, Mason, and Lewis Counties have not been received. The money loss from all sources in Pierce County is perhaps as great as in King County ($125,000), since there was much damage to bridges and highways, and the suspension of some mills.

The railroads suffered greatly from slides, washouts, and damage to bridges, which loss is not included in the foregoing.

The total loss in the flooded district is probably somewhat less than $1,000,000 all told.

In comparison with former floods this one is in dispute. The Skagit and Snohomish Rivers were probably higher than ever before in their history. It is difficult to compare the past flood with former stages of the rivers and especially with periods of more than 10 years ago, because since the introduction of automobiles, the nature of road building has changed so much. Also dikes have been constructed, channels narrowed, banks revetted, mouths dredged or on the contrary allowed to become filled up with silt, thus materially changing the condition of the rivers. The expense of constructing modern highways is so manyfold greater than that of the old dirt road that the cost of repairs or replacements forms no basis of comparison with former conditions. Besides there are no reliable gauges in the flooded areas to mark the stages, and therefore no reliable comparisons can be made.

Floods in southern California, H. B. Hersey,[1] Meteorologist, Los Angeles.—A remarkably heavy rainfall occurring over southern California from the 17th to the 28th of December caused flood conditions in many localities. There had been practically no rain up to the 17th, when it began at a few points and on the 18th it became general and heavier. It continued raining nearly every day at most stations until the 28th, when it ended.

The precipitation was heaviest in the mountainous districts, but even on the desert there was considerable rain. One station, Opid's Camp, located about 5 miles northeast of Mount Wilson, recorded a total precipitation of 49.01 inches; three other stations reported between 30 and 40 inches and 13 others between 20 and 30 inches. Most of the precipitation was in the form of rain except at altitudes above 8,000 feet where a large portion of it was snow.

The ground was very dry and for the first three days absorbed a great portion of the rainfall except in the mountainous districts, so the damage was not so extensive as would be expected from such a heavy precipitation. Many roads were washed out and made impassable and several bridges were carried away and others damaged. Some cattle and other stock were drowned, but losses in this line were not important. No lives were lost, though many people had narrow escapes.

The highest reading of the river gauge at Los Angeles was made at noon of the 20th, when it read 12.5 feet. Mud marks on the gauge at that time showed that the water had been about a foot higher during the forenoon.

Mr. W. P. Hoge, special observer at Mount Wilson,[1] called this office by telephone about noon of the 20th and reported the excessive rainfall occurring since the morning observation. Warnings were immediately telephoned to the flood-control office, several railroad offices, and other affected by high water.

The check dams and reservoirs put in by the county flood-control board proved to be of great value and this work will undoubtedly be greatly extended.

[1] See page 660, this REVIEW.

Flood stages during December, 1921.

River and station.	Flood stage.	Above flood stages—dates.		Crest.	
		From—	To—	Stage.	Date.
GREAT LAKES DRAINAGE.					
Grand:	*Feet.*			*Feet.*	
Grand Rapids, Mich	11.0	21	21	11.2	21
MISSISSIPPI DRAINAGE.					
Ohio:					
Marietta, Ohio	33.0	(*)	1	34.0	1
Point Pleasant, W. Va	40.0	(*)	2	43.4	1
Do	40.0	25	27	43.9	25
Dam No. 29, Ky	50.0	1	1	50.5	1
Do	50.0	26	27	52.5	26
Dam No. 30, Ky	50.0	26	28	52.2	26
Portsmouth, Ohio	50.0	26	28	53.5	27
Maysville, Ky	50.0	26	28	52.3	27
Cincinnati, Ohio	50.0	25	30	56.1	27
Dam No. 35, Ky	45.0	26	29	50.3	27
Madison, Ind	46.0	26	29	47.9	28
Louisville, Ky	28.0	26	30	32.3	28
Cloverport, Ky	40.0	25	(†)	46.9	29
Henderson, Ky	33.0	1	10	37.5	7
Do	33.0	26	(†)	41.2	31
Evansville, Ind	35.0	(*)	10	39.6	6
Do	35.0	26	(†)	43.1	30
Mount Vernon, Ind	35.0	2	10	38.8	7
Do	35.0	27	(†)	42.5	31
Shawneetown, Ill	35.0	1	11	39.6	8
Do	35.0	27	(†)	43.2	31
Monongahela:					
Lock No. 15, W. Va	22.0	24	25	27.2	24
Lock No. 10, W. Va	25.0	24	24	27.0	24
Lock No. 7, Pa	30.0	24	25	36.4	24
Lock No. 4, Pa	31.0	25	25	38.8	25
Little Kanawha:					
Glenville, W. Va	23.0	24	24	26.4	24
Creston, W. Va	20.0	24	24	21.0	24
Walhonding:					
Walhonding, Ohio	8.0	25	25	8.4	25
Hocking:					
Athens, Ohio	17.0	24	26	20.9	25
Scioto:					
Circleville, Ohio	10.0	25	26	12.0	25
Chillicothe, Ohio	14.0	25	26	14.7	26
Licking:					
Farmers, Ky	25.0	25	25	25.6	25
Falmouth, Ky	28.0	24	26	40.8	24
South Fork of Licking:					
Cynthiana, Ky	20.0	24	24	22.6	24
Green:					
Lock No. 4, Ky	33.0	(*)	2	38.9	1
Lock No. 2, Ky	34.0	1	8	37.0	5
Do	34.0	28	(†)	35.8	30
Wabash:					
Vincennes, Ind	14.0	1	3	16.0	1
Mount Carmel, Ill	15.0	(*)	9	21.3	1
Do	15.0	25	(†)	20.4	31
White:					
Decker, Ind	18.0	(*)	2	19.5	1
Do	18.0	5	7	18.5	6
Do	18.0	26	(†)	22.7	31
East Fork of White:					
Shoals, Ind	20.0	25	(†)	28.1	29
Williams, Ind	10.0	26	(†)	17.3	28

* Continued from November, 1921. † Continued into January, 1922.

Flood stages during December, 1921—Continued.

River and station.	Flood stage.	Above flood stages—dates.		Crest.	
		From—	To—	Stage.	Date.
MISSISSIPPI DRAINAGE—continued.					
West Fork of Whirte:	*Feet.*			*Feet.*	
Elliston, Ind	19.0	3	3	19.1	3
Do	19.0	25	28	22.8	27
Illinois:					
Peru, Ill	14.0	(*)	(†)	16.6	19
Henry, Ill	7.0	22	(†)	9.1	27, 29
Peoria, Ill	16.0	1	(†)	17.6	24
Havanna, Ill	14.0	4	15	14.4	7–10
Do	14.0	21	29	14.4	25–26
Beardstown, Ill	12.0	(*)	(†)	14.0	6–11
Willamette:					
Eugene, Oreg	10.0	1	3	14.3	2
Albany, Oreg	20.0	2	4	23.0	2
Salem, Oreg	20.0	2	3	21.2	3
Oregon City, Oreg	12.0	2	5	13.9	4
Portland, Oreg	15.0	2	5	16.3	4
Santiam:					
Jefferson, Oreg	10.0	(*)	2	13.0	1

* Continued from November, 1921. † Continued into January, 1922.

MEAN LAKE LEVELS DURING DECEMBER, 1921.

By UNITED STATES LAKE SURVEY.

[Detroit, Mich., Jan. 5, 1922.]

The following data are reported in the "Notice to Mariners" of the above date:

Data.	Lakes.*			
	Superior.	Michigan and Huron.	Erie.	Ontario.
Mean level dur ng December, 1921:	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Above mean sea level at New York	601.99	579.54	571.71	244.83
Above or below—				
Mean stage of November, 1921	−0.21	−0.10	−0.09	−0.02
Mean stage of December, 1920	−0.26	−0.56	−0.18	−0.57
Average state for December, last 10 years	−0.39	−0.62	−0.09	−0.68
Highest recorded December stage	−1.14	−3.04	−1.82	−2.78
Lowest recorded December stage	+0.79	+0.54	+0.85	+1.40
Average relation of the December level to:				
November level	.....	−0.10	−0.10	−0.10
January level	.....	+0.20	+0.20	+0.10

* Lake St. Clair's level: In December, 574.58 feet.

EFFECT OF WEATHER ON CROPS AND FARMING OPERATIONS, DECEMBER, 1921.

By J. WARREN SMITH, Meteorologist.

The month of December, 1921, was generally mild in all sections of the country, except in the Northeast and far Northwest, where the temperatures averaged below normal. It was mostly favorable for outdoor work, especially in Central and Southern States and much plowing was accomplished in the South. There was a serious lack of moisture in the central and southern Great Plains area and parts of the Southwest, but generous rains in California the latter part of the month were very beneficial in that State, while at the same time needed rains occurred in the Southeast. Corn husking made generally good progress and at the close of the month corn was about all gathered in the principal producing States, although floods did some damage to the crop in fields in portions of the Ohio Valley.

There was a general absence of snow cover during most of the month in the principal winter wheat States, but there was not much damage reported from alternate freezing and thawing, as temperatures remained comparatively uniform. Fall-sown grains continued in satisfactory condition east of the Mississippi River, but the continued lack of moisture was harmful in the Great Plains area from Nebraska southward and wheat showed a steady deterioration in most of that section.

Hardy truck crops in the South suffered no material frost damage during the month, but tender vegetation was seriously injured in some southern localities the first half. Precipitation in the east Gulf States favorably affected truck in that area, but it continued too dry in the Southwest. Cane harvest made good progress in Louisiana, and the weather was favorable for stubble and fall planted cane in that State, while it was ideal for truck in the Imperial Valley of California.

The mild, open weather was favorable for stock in the Central and Eastern States, and considerable grazing was possible. It was also favorable for range and stock in the West except where drought prevailed in the Southwest. Considerable feeding was necessary in the far Northwest